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ASSESSMENT OF NOISE EXPOSURE PRODUCED BY VARIATIONS IN LANDING APPROACH PROCEDURES AT SAN JOSE MUNICIPAL AIRPORT

BOLT BERANEK AND NEWMAN, INCORPORATED

PREPARED FOR
ENVIRONMENTAL PROTECTION AGENCY

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BBN REPORT 2589

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By
John F. Mills

August 1973

Contract No. 68-01-1835

Submitted to:

Office of Noise Control Programs
U.S. Environmental Protection Agency
Crystal Mall Building No. 2, Room 1107
Washington, D.C. 20460

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ASSESSMENT OF NOISE EXPOSURE PRODUCED BY VARIATIONS IN LANDING APPROACH PROCEDURES AT SAN JOSE MUNICIPAL AIRPORT

I. INTRODUCTION

The Environmental Protection Agency (EPA), in response to the requirements of the Noise Control Act of 1972, must study the adequacy of current and planned regulatory action of the Federal Aviation Administration (FAA) in the exercise of FAA authority to abate and control aircraft/airport noise. One of the specific requirements is to study the "adequacy of flight and operational noise controls", and to develop proposed regulations for submission to FAA where EPA determines that such regulations are "necessary to protect the public health and welfare".

In support of the EPA investigation of the use of aircraft operational procedures as means for noise control, Bolt Beranek and Newman Inc. has performed a series of noise measurements at San Jose Municipal Airport. These measurements were made to evaluate the effectiveness of different aircraft approach procedures, as used in normal practice by several different airlines, in reducing noise received on the ground in the vicinity of the airport.

San Jose is located in the San Francisco Bay area, approximately 30 miles southeast of San Francisco and Oakland. The airport is an intermediate stop for a significant proportion of the passenger traffic between Southern California terminals, Los Angeles, Hollywood-Burbank, Ontario and San Diego, and the Bay Area. The majority of flights are by two intra-state carriers, Pacific Southwest Airlines and Air California. The remainder of the jet operations consist of Hughes Air West, United Airlines and Continental Airlines, with one flight per day by Western Airlines, the only four-engine jet aircraft scheduled during the study period. Commuter flights and other flights of propeller aircraft were not considered in the program.

San Jose was chosen for this study because it presented an opportunity to study the effects in actual day-to-day operations of procedures developed for two and three-engine jet aircraft aimed at reducing noise in the area under the landing approach.

The procedures in use at San Jose Municipal Airport (SJC) have undergone several changes in an effort to reduce the noise exposure. The area of primary interest in this study is under the extended centerline of Runway 30L, which has an instrument landing system (ILS), and is used for most landings of air carrier aircraft.

The approach procedures currently in use have been tailored to suit the particular situation at San Jose, and consider the following major factors:

1. A significant proportion of the aircraft landing at SJC are from Oakland or San Francisco, approximately 30 miles northwest.

2. During most of the time, the weather at SJC is suitable for visual approaches, where the aircraft is positioned by visual contact with the airport rather than by the exclusive use of radio navigation aids.

3. Most operations are by intra-state carriers over short stage-lengths and over the same routes, allowing increased pilot familiarity with each airport situation, and more frequent landings than would occur for longer flights.

The short distances involved for flights from San Francisco and Oakland make it impractical to use the same high cruising altitudes normally associated with jet aircraft. For some time, the flights from Oakland, weather permitting, were routed down the San Francisco Bay, past Moffet Naval Air Station, to enter a left downwind pattern. Initially, there were no prescribed procedures for setting up the aircraft in the landing configuration. The result was that, at the pilot's descretion, the

aircraft were on occasion in level flight at a fairly low altitude in the landing configuration, requiring appreciable power and therefore generating considerable noise. All flights using the procedure followed essentially the same path over the ground, causing appreciable exposure in some areas.

Three major changes occurred to create the present situation. The FAA implemented their "keep-'em-high" program, which requires the aircraft to remain above a specified altitude until entering the descent area. The routing was changed, resulting in a spreading of the flight paths, and the two intra-state carriers, Pacific Southwest Airlines and Air California, initiated the use of two-segment approaches under visual flight conditions.

The situation at San Jose provided an excellent opportunity to evaluate the effectiveness of the various procedures in actual day-to-day operations. Detailed descriptions of the procedures, measurement program and analyses are given in the following sections.

II. NOISE MEASUREMENT PROCEDURES

A. Site Locations

Portable noise monitoring units were located at two sites, designated 1 and 250, during the measurement period. Tape-recorded data was taken at three sites, designated 2, 3 and 4. All sites were under or adjacent to the extended centerline of runway 12R/30L. Table I lists the locations with respect to the threshold of runway 30L, and the locations are shown in Figure 1.

B. Noise Data Acquisition

Measurements at sites 1 and 250 (250 N. Autumn Street) were made with portable noise monitoring systems previously developed by BBN. Each system is completely self-contained and is powered by a 12 volt automotive battery. Figure 2 shows a block diagram of the noise monitor instrumentation. Each system is comprised of: (1) a microphone and preamplifier, (2) a monitor control unit, and (3) a digital magnetic tape unit.

The system uses a General Radio one-inch ceramic microphone (Model 1560-P40). The microphone and preamplifier were protected from wind and dust by an Electrovoice open cellular foam windscreen (Model 355). The microphone was mounted on a pole approximately six feet above ground level.

The noise signal from the microphone preamplifier was fed to a sound level monitor unit (BBN Model 704) which consists of an amplifier, a frequency weighting network, a logarithmic detector unit and an analog-to-digital converter. The signal first passes through a standard A-weighting filter, and then goes to a rms (root-mean-square) detector. The detector has a dynamic range of 100 dB and the averaging characteristics conform to those of the "slow" meter setting of a standard sound level meter. The output of the rms detector is a dc voltage proportional to the rms signal input. From the detector the signal goes to a threshold comparator. The comparator detects whether or not the sound level has exceeded a preset threshold level. The threshold level is set, typically, slightly higher than the ambient noise level at the site.

While the sound level is below the threshold, the monitor remains in a quiescent state and no permanent record of the sound level is maintained. When the threshold is exceeded, the signal passes to an analog-to-digital magnetic tape. As long as the threshold is exceeded, the monitor system continues to record the A-weighted sound level every one-half second. When the sound level drops below the threshold, the monitor system ceases to record sound level data, and records the time of day on the digital tape before returning to the quiescent state. Thus, only significant events and the time of occurrence are recorded.

The monitor system determines the sound pressure level to an accuracy of 0.1 dB. However, recording of the 0.1 dB digit on tape can be suppressed in order to extend the amount of sound level information which can be recorded on a given length of digital tape. This means that the sound level is truncated to the next lowest decibel. All monitor system data for this study (with the exception of the calibration signal) were recorded to one decibel accuracy. As a consequence, the noise level indices computed from this data are biased downward by 0.5 dB. All measured sound level information presented in this report has been corrected for this bias.

Instrument calibration and system checks were performed on a daily basis. End-to-end acoustic calibration was performed using a General Radio Acoustic Calibrator (Model 1562A). The recorded calibration signal was later analyzed during data reduction as a check on system performance and as a calibration standard for the noise data.

In addition to the two noise monitor locations, noise data was recorded on analog tape at three other positions. These recordings were made using a system consisting of a microphone and preamplifier, a sound level meter and a magnetic tape recorder. A Bruel and Kjaer (B&K) 1/2 inch condenser microphone (Model 4133), General Radio (GR) microphone preamplifier (Model 1560-P42) and

an Electrovoice windscreen (Model 355) were used. The signal from the microphone preamplifier was connected to a B&K sound level meter (Model 2203). The signal from the sound level meter was fed to a Nagra III tape recorder. End-to-end instrument calibration was performed at frequent intervals using a B&K Pistonphone (Model 4220). During analysis of the tape, the standard pistonphone signal provided both a calibration standard and a check on system stability.

As each event was recorded, a photograph of the aircraft was taken as it passed by the site. The photograph provided identification and was also used to determine the distance of closest approach by scaling known dimensions from the photograph.

C. Noise Data Reduction

The acoustic analysis of the noise monitor data was performed by entering the data from the digital tapes into a small digital computer (Digital Equipment Corporation PDP-8). The computer performed the necessary computations to determine the noise measures. A detailed discussion of the noise measures and method of calculation is presented in Section III. The computer reports each noise intrusion sensed by the monitor system, the time of day it occurred, and the noise level of the intrusion. In addition, it computes hourly and daily indices of the noise environment.

Analysis of the analog tape recordings was performed using a real time audio spectrum analyzer and a digital computer. The analog tapes were played back into a Hewlett-Packard one-third octave band audio spectrum analyzer (Model 8054A). As each recorded aircraft flyover was played back, the computer read the one-third octave band spectrum (50 Hz to 10 kHz) every one-half second and calculated the various noise measures. The recorded pistonphone signal provided the calibration reference used in computing the noise indices.

D. Observed Flight Paths

During the course of normal operations on May 11, 1973, the routings of twelve aircraft were observed on the Bay Approach Control radar. The flights from the south were established on the final approach course at a considerable distance from the airport. Nominally the flight tracks of aircraft from the north would pass over the Woodside VOR (a radio navigation aid located approximately 20 miles northwest of San Jose). In practice it was observed that these aircraft were distributed over a band approximately five miles wide southeast of Woodside, narrowing to approximately two miles before turning onto final approach. All the aircraft observed turned onto final approach inside the outer marker, at distances from two to four miles from the runway. Figure 1 shows the approximate range of observed flight paths.

III. ANALYTIC PROCEDURES

A. Noise Level Definition and Computation

The noise monitor units are designed to record A-weighted sound pressure levels and all the comparative noise data presented for these and the analog tape recordings are based on this measure. As part of the analog recording analysis, various other noise measures are also computed, based on perceived noise level (PNL).

In determining people's assessment of an aircraft sound, the intensity, frequency content and duration of the noise signal have been shown to be important attributes. A measure which takes these factors into account is the Single Event Noise Exposure Level, SENEL, as defined in the California Noise Standards, Reference 1. This measure is identical to the Sound Exposure Level, SEL. The SEL is computed by integrating with time the A-weighted sound level over the upper 20 dB(A) of the signal:

$$SEL = 10 \log\left[\int_{T_1}^{T_2} \text{antilog}\left(\frac{AL[t]}{10}\right) dt \right] \qquad (1)$$

where: AL[t] = instantaneous A-level at time t, and T_1 and T_2 bracket the time during which the noise signal is within 20 dB(A) of its maximum value.

Equation (1) defining the SEL implies a continuous time integration of the A-weighted sound level during the time the signal is within 20 dB(A) of its maximum level. However, in using digital techniques, it is desirable to approximate this integration by a summation, replacing dt with a Δt of 0.5 seconds. Noise levels are sampled at 0.5 second intervals and summed according to the following equation:

$$SEL = 10 \log\left[\sum_{i=1}^{n} \text{antilog}\left(\frac{AL_i}{10}\right) \cdot 0.5\right] \qquad (2)$$

where: AL_i = A-level for sample i

n = total number of samples for which the noise level is within 20 dB(A) of the maximum AL_i

For typical flyover noise signals, random discrepancies of up to ±0.2 dB may occur between the "summation" and the "integral" equations. The mean value of the discrepancy is zero.

B. Analysis of Measured Noise Levels

The noise monitor systems record all transient noise intrusions above the set threshold. The recorded data is then processed by digital computer to provide a summary description of the noise intrusions. A typical listing of this summary is shown in Figure 3. The listing shows a portion of the data obtained at measurement

Site 250 on May 11, 1973. For each noise intrusion the computer tabulates the time of occurrence, the maximum A-level, the duration (in seconds) for which the signal was within 10 dB of the maximum, and the SENEL. The computer also tabulates the Hourly Noise Level (HNL) for each hour of the day. These tabulations provide the basic data utilized in this study.

A listing of a typical analog recording is shown in Figure 4. In addition to the SENEL (or SEL), various other noise measures are tabulated, including Perceived Noise Level (PNL) and Effective Perceived Noise Level (EPNL).

Based on the logs kept by San Jose tower personnel during the measurement period and notes made in the field from monitoring the Bay Approach Control radio frequency, each flight was related to the appropriate noise intrusion at the monitor sites and to the analog recordings at Sites 2, 3 and 4. The noise levels were then listed by aircraft type and airline. Tables II through VI show the SEL and, where applicable, the measured distance of closest approach.

IV. COMPARISONS OF PROCEDURES

In evaluating the effects of the procedures used, it is of interest to compare the results with expected values based on previous measurements of ILS approaches, and to make a comparison among the procedures.

A. Comparisons With Previously Used Curves

Relationships of noise level versus distance have been developed for use in noise exposure calculations, see Reference 2, and these relationships were used for comparison. The flights for which distance information was available, i.e., data from Sites 2, 3 and 4, were separated by airline and a regression analysis was performed. Over the range of distances measured, the referenced SEL versus distance curves are approximately straight lines when plotted on a scale of dB versus the logarithm of distance. The regression analysis was made on this basis. Figures 5 through 9 show, for DC-9, 727 and 737 aircraft in use by different airlines, the individual noise events, the regression lines computed for the points, and the SEL versus distance curves previously used to compute noise exposure for ILS approaches.

All the regression lines are below the standard curves, in amounts varying up to approximately 4 dB, with the exception of the line for United aircraft, where there appears to be an insufficient range of distances to provide a reliable slope.

An additional point of interest in these graphs is the distribution of the distance information. The range of distances measured at a given position is much wider for the PSA and Air California aircraft than for United, Air West and Continental, reflecting the variability in pilot techniques and the absence of a positive vertical guidance system.

B. Comparisons Between Airlines

During initial reviews of the data it appeared that there was a difference in noise levels between aircraft making straight-in approaches and aircraft turning onto final approach close to the airport. Most of the aircraft in the latter group did not pass over the monitor station at Site 1, approximately four miles from the airport, so no record was obtained at this site. The data at other stations were separated into two groups using this as a criterion. Group 1 was defined as aircraft which were detected at both monitor sites, and Group 2 was defined as those aircraft which were not detected at monitor Site 1.

Figures 10 and 11 show the noise levels at each of the five sites. At Sites 2 and 4 there were not enough data to warrant separation between groups, so all the information is combined at these sites. The median levels (50% of the data are above this level) are also shown on these figures.

Different ways of expressing the data are useful to illustrate different features. The figures show the median level, for example. To determine if the difference in the samples obtained is statistically significant, the arithmetic means of the noise levels are used. An analysis of the levels involving calculation of the means and standard deviations permits comparison by means of a t-test. The criterion chosen was a test at the 95% significance level. Based on this, there is a statistically significant difference at Site 250 between the following pairs in the two-engine category:

Air California Group 1 and Air California Group 2
Air California Group 2 and Air West Group 2

Other combinations were not sufficiently different to show significance at the specified level.

At Site 3 a significant difference was found between Air California Group 1 and Air California Group 2. No other differences were found to be significant.

In comparing the three-engine aircraft at Site 250 there is a statistically significant difference between the following groups:

PSA Group 1 and PSA Group 2
Continental Group 1 and Continental Group 2

At Site 3 the groups showing a significant difference are:

PSA Group 1 and PSA Group 2
United Group 1 and United Group 2

There was only one sample from Continental Group 2 which precluded comparisons involving this group. It is interesting to note that in all cases the t-test showed no marginal cases: the differences were either quite significant or quite small.

To determine the effect on noise exposure it is necessary to consider yet another analysis procedure. Cumulative exposure indices currently in use, such as Day/Night Average Level, DNAL, Community Noise Equivalent Level, CNEL, and Noise Exposure Forecast, NEF, and similar measures, use the principle of energy summation. The significant factor in determining exposure in this case is not the median or arithmetic average value, but the energy mean value. Higher values of individual events tend to influence the energy mean more than the arithmetic mean, and thus the energy mean is never less than the arithmetic mean. The difference is a function of the data spread, and is greater for large variations. Thus while the t-tests described previously are useful in determining if there is a significant difference, the magnitude of the difference is more accurately represented by the energy average difference.

The entire set of data is summarized in Tables VII and VIII which show the maximum, minimum, median, arithmetic average and energy average values for each site.

C. Effects on Noise Exposure Values

The noise exposure at a given location is a function of a number of variables, including aircraft mix, runway utilization, proportion of time that instrument approaches are required, etc. Therefore, in comparing procedures, it was considered more useful to compare single event contours, rather than contours of a composite measure.

Three sets of conditions were considered, covering the range of observations at San Jose:

1. ILS approach on a 3° glide slope.

2. The nominal two-segment approach used by Air California and PSA, consisting of a 5½° initial segment and a 3° final segment starting 1½ miles from the runway threshold.

3. An approach typical of some of the steeper approaches observed for Air California and PSA, consisting of an 8° initial approach and a 3° final approach starting at one mile from the runway threshold.

For the first case the previously referenced noise versus distance relationships were used. For the second and third cases the noise versus distance relationships were lowered by 4 dB for the initial, steep part of the approach. Figure 14 shows the SEL contours for the three types of approach.

V. CONCLUSIONS

The data shows that most aircraft at San Jose, when the weather is suitable for visual approaches, generate less noise than would be expected from aircraft stabilized on a 3° glide slope. The regression lines obtained for noise level versus distance show that the source noise is in general lower than that expected for an ILS approach by up to 4 dB. This is due to the reduced thrust associated with a steeper approach and lower flap settings.

Most approaches were flown appreciably above the 3° glide slope, thus providing greater separation between the noise source and the observer. The combined effect of these two factors in reducing the noise level observed on the ground was clearly demonstrated.

A general conclusion regarding the use of other than precision approaches (i.e., approaches having positive horizontal and vertical guidance) is that these approaches introduce an appreciable variability in the data, mostly resulting in lower noise levels. The spread in noise data for a given aircraft type at a particular position is approximately the same. However, on average, aircraft entering the traffic pattern from the north and using segmented approach procedures generate the least noise on the ground.

Specific conclusions regarding each procedure are discussed in the following paragraphs.

United Airlines

There were only four flights per day into San Jose, and the conclusions are somewhat indefinite due to the small sample. Of the three flights from San Francisco during the test period two apparently turned onto final approach inside Site 1, and were not detected at this site. Eight of the nine flights from Denver and Chicago were detected at Site 1.

Continental Airlines

Fourteen flights occurred during the test period, eight from Portland (north) and six from Burbank (south). All the flights from the south and four of the flights from the north were detected at Site 1. As a group, the data showed less variability than aircraft using segmented procedures. The levels were on average 7 dB lower at the furthest-out site and 2 dB lower at the closest site than would be predicted for ILS approaches.

PSA

The segmented approach procedure used by PSA gives rise to a considerable variability in altitude profiles. The resulting spread in noise levels at a particular site is approximately 15 dB between the noisier and quieter aircraft. The highest levels generated are comparable with those expected for an ILS approach.

Two distinct groups were identified, consisting of aircraft presumably using the same procedures, with different noise characteristics. No record was found at the furthest site, Site 1, for approximately one-third of all PSA flights. All but three flights from Oakland, which made turning approaches, were in this group, and also a number of flights from Burbank and Los Angeles, which were making straight-in approaches. Aircraft in the group not detected at Site 1 also generated significantly less noise at the closer-in sites, on average approximately 5 dB.

Hughes Air West

As a group the noise levels were 2 to 5 dB below those expected for an ILS approach. Two flights from the south were not detected at Site 1, and five flights out of twelve from Oakland and San Francisco were recorded at Site 1. There were no major differences in noise levels from turning approaches as opposed to straight-in approaches.

Air California

The procedures of Air California result in several effects. Only three flights out of twenty-three from Oakland or San Francisco were detected at Site 1, and two of the three occurred during conditions of low clouds early on May 10, when instrument approach procedures were necessary. This indicates that either the aircraft turned onto final inside Site 1 (as observed in the field

and from radar observations) or were high enough in altitude that the monitor noise threshold was not exceeded. Also significant was the fact that sixteen of the twenty-nine aircraft making straight-in approaches, directly over the site, were not detected at Site 1. These same aircraft showed noise levels approximately 8 dB lower at closer-in sites also.

In summary, it can be concluded that the turning type of approach creates less exposure than straight-in approaches, and that the potential exists for greater noise reduction for the straight-in approaches if more consistent flight profiles could be achieved, with all aircraft using the profiles observed for the quieter aircraft.

The reduction in overall exposure with the procedures currently in use, although statistically significant, would be moderate, 3 to 5 dB, because the higher noise levels generated by some aircraft have a larger influence on the cumulative (energy) exposure than the quieter flights. Evidently if the levels could be consistently reduced to those in the lower end of the data spread, the exposure reduction would become appreciable. Reductions in exposure of approximately 10 dB could be expected at all sites beyond about one mile from the runway threshold for this situation.

REFERENCES

1. California Noise Standards. Department of Acoustics, Title 4. (Register 70, No. 48-11-28-70) Subchapter 6.

2. Aviation Noise Evaluations and Projections. Prepared for the Regional Airport Systems Study.

TABLE I

SITE LOCATIONS

Site Number	Distance from Threshold, ft.	Height of 3° Glide Slope, ft.
1	23,400	1,276
2	15,700	873
3	12,200	689
4	19,400	1,067
250	9,400	543

TABLE II

NOISE LISTING AIR CALIFORNIA BOEING 737

Date	Time (PDT)	Flight No.	Site 1 SEL	Site 2		Site 3		Site 250 SEL
				Dist.	SEL	Dist.	SEL	
5/8/73	1619	350	82.0					
	1655	349	82.9					
	1725	449	87.4				93.6	98.1
	1806	658	--			1608	82.3	91.5
	1824	657	90.4			652	96.7	103.5
	1833	558	80.1			731	98.0	102.7
	1933	268	--					103.9
	2053	563	87.8					102.1
	2147	677	--					101.3
								101.9
5/9/73	0722	902	89.0					103.2
	0756	606	89.7					---
	0927	505	95.0			670	99.2	100.9
	0957	605	81.0			804	92.2	90.6
	1052	616	--	2224	80.6	1508	84.5	89.9
	1111	711	--			1221	85.1	90.6
	1153	619	--					89.8
	1343	734	82.4					---
	1403	434	--					89.8
	1430	636	--					94.3
	1434	623	--					93.4
	1620	350	--					95.2
	1702	349	94.7	1608	87.8	1177	89.0	92.3
	1724	449	--	1532	86.7		86.7	96.1
	1806	658	--				88.5	99.3
	1823	657	--	1191	87.8			83.7
	1830	550	--					93.0
	1930	268	--					90.2
	2051	563	--					98.2
	2135	677	87.8					

-Continued-

TABLE II

(Continued)

Date	Time (PDT)	Flight No.	Site 1 SEL	Site 4		Site 3		Site 250 SEL
				Dist.	SEL	Dist.	SEL	
5/10/73	0702	502	Landed on Runway 12R					
	0717	902	--					97.3
	0746	606	--					95.5
	0853	605	--					93.4
	0923	505	--			995	83.7	90.7
	1023	616	--	5361	74.3	2144	80.1	89.8
	1100	711	88.8	1049	95.3	699	96.8	99.4
	1158	-	--	1582	83.1	885	87.8	92.1
	1347	734	--					95.5
	1404	434	--					92.4
	1417	623	--					88.4
	1436	636	--					95.8
	1621	350	--			1237	86.6	89.3
	1702	349	85.1	1304	89.3	846	92.6	98.0
	1725	449	--	1556	85.7	731	91.9	99.5
	1806	658	--	2144	82.8	1049	89.2	97.6
	1826	657	80.2	1462	84.8	893	90.5	97.9
	1832	558	--			1664	83.1	91.5
	1932	268	--			2354	79.7	87.6
	2051	563	82.4					101.0
	2145	677	85.3					100.3
5/11/73	0704	502	--			1038	91.3	100.4
	0718	102	Landed on Runway 12R					
	0748	606	--			1556	83.3	89.4
	0800	701	--			1200	84.1	93.1
	0855	605	--			1419	83.3	89.3
	0928	710	--					93.8
	1023	616	--					89.3
	1107	505	87.7					100.7
	1130	617	85.4					96.4
	1247	628	--					88.8
	1310	719	--					93.2
	1411	623	--					89.8
	1432	732	--					95.5

TABLE III

NOISE LISTING AIR WEST DOUGLAS DC-9

Date	Time (PDT)	Flight No.	Site 1 SEL	Site 2		Site 3		Site 250 SEL
				Dist.	SEL	Dist.	SEL	
5/8/73	1239	749	--					
	1657	478	91.5					
	1820	818	--			712	92.0	101.3
	1931	4	91.9					102.9
	2229	956	--					103.0
5/9/73	0739	941	92.6					103.4
	0853	3	92.1					103.4
	1136	744	90.7					100.9
	1243	749	81.1	1253	86.1	934	87.8	92.0
	1700	748	95.3	1187	91.9	898	92.7	96.3
	1820	818	8.13	1481	87.9			99.0
	2016	4	85.1					101.4

Date	Time (PDT)	Flight No.	Site 1 SEL	Site 4		Site 3		Site 250 SEL
				Dist.	SEL	Dist.	SEL	
5/10/73	0738	941	--					98.3
	0839	3	--					101.1
	1124	744	--					93.4
	1241	749	--	3353	78.4	1781	81.6	85.0
	1709	748	85.9	1239	90.2	781	96.6	101.7
	1819	818	--	3800	78.5	1075	91.7	98.8
	1928	4	86.3			750	96.4	102.5
	2211	956	84.4					102.1
5/11/73	0736	941	82.3			1000	92.6	100.2
	0842	3	--			1086	91.7	97.8
	1125	744	89.3					100.7
	1239	749	--					99.7

TABLE IV

NOISE LISTING PSA - BOEING 727

Date	Time (PDT)	Flight No.	Site 1 SEL	Site 2		Site 3		Site 250 SEL
				Dist.	SEL	Dist.	SEL	
5/8/73	1217	201						
	1226	263						
	1404	203						
	1406	361						
	1518	302	80.7					
	1523	363	77.6					
	1703	461	84.5					
	1705	304	90.1			866	85.4	
	1813	503	86.5			720	96.3	101.7
	1827	463	84.1			670	101.1	105.7
	1917	401	86.5					105.2
	1951	561	81.6					98.2
	2032	404	--					103.9
	2102	403	89.3					103.6
	2125	563	87.2					102.5
5/9/73	0754	161	94.4					104.5
	0857	101	98.3					106.2
	0929	163	92.2			731	97.9	97.8
	1006	104	82.7	1143	94.5	901	96.0	101.8
	1058	261	82.4	1259	92.8	931	93.9	102.1
	1134	103	83.4					97.4
	1219	201	82.9	1000	90.6			98.4
	1230	263	80.0	1545	86.4	1106	89.1	93.6
	1353	361	82.8					102.1
	1406	203	82.2					100.1
	1517	302	--					91.5
	1525	363	78.0					101.7
	1657	461	95.8	1088	92.3	791	96.2	99.7
	1704	304	79.9	1333	93.8			102.2
	1809	503	84.3	1115	91.5		92.9	99.0
	1822	463	80.3	985	93.5			103.4
	1920	401	--	1889	83.4	1097	91.3	99.9
	2001	561	80.8					103.9
	2033	404	--					101.3
	2100	403	--					98.6
	2126	563	89.2					101.4

-Continued-

TABLE IV

(Continued)

Date	Time (PDT)	Flight No.	Site 1 SEL	Site 4		Site 3		Site 250 SEL
				Dist.	SEL	Dist.	SEL	
5/10/73	0750	161	83.5					103.6
	0847	101	82.4					104.9
	0925	163	82.9					101.1
	1012	104	--	2636	80.6	1062	93.1	95.8
	1057	261	87.1	1658	91.8	756	95.2	100.7
	1149	103	91.7					100.8
	1228	263	--	2125	82.7	1172	86.3	91.6
	1358	361	82.3					102.3
	1401	201	--					94.7
	1408	203	87.7					96.1
	1520	302	--			1463	88.3	95.7
	1536	363	--			1308	88.7	93.4
	1705	461	81.7	1545	87.2	829	91.6	101.7
	1707	304	--	2429	82.6	1346	85.4	90.1
	1801	503	--	2193	82.1	1152	86.6	93.5
	1824	463	--	1600	85.5	800	95.8	100.9
	1913	401	79.2			861	89.9	98.9
	2030	404	--					92.4
	2041	561	--					100.4
	2100	403	--					105.9
	2140	543	85.2					102.8
5/11/73	0758	161	--					96.2
	0846	101	80.7			1133	86.1	97.8
	0926	163	81.3					95.6
	1002	104	83.5					90.2
	1030	103	81.1					92.5
	1053	261	80.0					96.8
	1102	1012	82.9					100.3
	1149	202	--					98.9
	1215		--					96.7
	1224	201	89.0					102.6
	1358	361	--					92.3
	1405	203	--					92.0

TABLE V

NOISE LISTING UNITED AIRLINES BOEING 727

Date	Time (PDT)	Flight No.	Site 1 SEL	Site 2		Site 3		Site 250 SEL
				Dist.	SEL	Dist.	SEL	
5/8/73	1803	917	87.7			866	94.6	101.9
	2059	717	92.7					103.7
5/9/73	0743	208	95.1					105.3
	1212	943	79.4	1172	86.1	841	94.2	99.5
	1833	917	86.4	1208	90.5			96.5
	2114	717	91.9					100.5

Date	Time (PDT)	Flight No.	Site 1 SEL	Site 4		Site 3		Site 250 SEL
				Dist.	SEL	Dist.	SEL	
5/10/73	0741	208	--					99.9
	1221	943	88.6	1126	91.6	670	95.3	98.5
	1813	917	--	1966	73.5	923	87.3	97.2
	2102	717	91.5					103.1
5/11/73	0739	208	--			667	90.6	98.9
	1219	943	82.1					99.1

TABLE VI

NOISE LISTING CONTINENTAL BOEING 727

Date	Time (PDT)	Flight No.	Site 1 SEL	Site 2		Site 3		Site 250 SEL
				Dist.	SEL	Dist.	SEL	
5/8/73	1949	308	87.8					96.0
	2040	307	84.8					104.4
5/9/73	1014	302	87.8	1062	94.5	805	97.4	101.6
	1024	301	82,8	1106	89.1	743	93.5	99.1
	1325	303	--	3022	79.3	1915	82.7	92.0
	1906	308	87.5	786	94.2	648	95.0	101.9
	2036	307	--					98.0

Date	Time (PDT)	Flight No.	Site 1 SEL	Site 4		Site 3		Site 250 SEL
				Dist.	SEL	Dist.	SEL	
5/10/73	1001	302	86.0	1062	93.5	712	94.9	100.7
	1042	301	89.3	1143	96.7	731	97.8	98.7
	1330	303	82.7	1478	86.9	720	96.1	100.9
	1905	308	84.2	1062	91.2	764	97.9	103.8
	2112	307	--					97.9
5/11/73	0951	302	86.2					96.2
	1032	301	--					90.3

TABLE VII

NOISE SUMMARY BOEING 737/DOUGLAS DC-9

Site	Airline*	Group*	No. of Events	Maximum Value	Minimum Value	Median	Arith. Average	Energy Average
1	XK	1	18	95.0	80.1	85.5	86.7	88.8
1	RW	1	13	95.3	81.1	86.3	87.6	89.7
4	XK	All	7	95.3	74.3	84.8	85.0	88.8
4	RW	All	3	90.2	78.4	-	82.4	86.0
2	XK	All	4	87.8	80.6	-	85.7	86.5
2	RW	All	3	91.9	86.1	-	88.6	89.3
3	XK	1	8	98.0	89.0	93.0	93.7	94.7
3	XK	2	18	99.2	79.7	85.0	86.1	89.6
3	RW	1	5	96.6	87.8	92.7	93.2	94.2
3	RW	2	4	92.0	81.0	-	89.3	90.7
250	XK	1	17	103.3	89.8	100.3	99.4	100.3
250	XK	2	40	103.9	83.7	92.3	92.9	95.1
250	RW	1	13	103.4	91.9	101.4	100.5	101.2
250	RW	2	9	103.0	85.0	98.8	97.6	99.4

* XK = Air California
RW = Hughes Air West

Group 1 consists of aircraft detected at Sites 1 and 250
Group 2 consists of aircraft detected only at Site 250

TABLE VIII

NOISE SUMMARY BOEING 727

Site	Airline*	Group*	No. of Events	Maximum Value	Minimum Value	Median	Arith. Average	Energy Average
1	PSA	1	40	98.3	78.0	83.0	84.7	88.1
1	UAL	1	9	95.1	79.4	87.7	88.4	90.5
1	CO	1	10	89.3	82.7	86.1	85.9	86.4
4	PSA	All	7	91.8	80.6	82.7	84.6	86.4
4	UAL	All	2	91.6	73.5	-	82.6	88.7
4	CO	All	4	96.7	86.9	-	92.1	93.4
2	PSA	All	9	94.5	83.4	92.3	91.0	92.0
2	UAL	All	2	90.5	86.1	-	88.3	88.8
2	CO	All	4	94.5	79.3	-	89.3	92.0
3	PSA	1	12	101.1	86.1	95.2	94.4	95.8
3	PSA	2	9	95.8	85.4	89.1	89.4	90.7
3	UAL	1	3	95.3	90.3	-	94.7	94.7
3	UAL	2	2	90.6	87.3	-	89.0	89.3
3	CO	1	7	97.9	93.5	96.1	96.1	96.4
3	CO	2	1	82.7	82.7	-	-	-
250	PSA	1	40	106.2	90.2	101.7	100.6	101.7
250	PSA	2	21	106.0	90.1	96.2	96.5	98.8
250	UAL	1	9	105.3	96.5	100.5	100.9	101.7
250	UAL	2	3	99.9	97.2	-	98.7	98.8
250	CO	1	10	104.4	96.0	99.1	100.3	101.1
250	CO	2	4	98.0	90.3	-	94.6	95.8

* PSA = Pacific Southwest Airlines
UAL = United Airlines
CO = Continental Airlines

Group 1 consists of aircraft detected at Sites 1 and 250
Group 2 consists of aircraft detected only at Site 250

TABLE IX

HEIGHT SUMMARY BOEING 737/DOUGLAS DC-9

Site	Airline*	Group*	No. of Events	Maximum Value	Minimum Value	Median
4	XK	All	7	5361	1049	1556
4	RW	All	3	3800	1239	--
2	XK	All	4	2224	1191	1560
2	RW	All	3	1481	1187	--
3	XK	1	8	1177	652	731
3	XK	2	18	2354	670	1200
3	RW	1	5	1000	750	898
3	RW	2	4	1781	712	1086

* XK = Air California
  RW = Hughes Air West

Group 1 consists of aircraft detected at Sites 1 and 250
Group 2 consists of aircraft detected only at Site 250

TABLE X

HEIGHT SUMMARY BOEING 727

Site	Airline*	Group*	No. of Events	Maximum Value	Minimum Value	Median
4	PSA	All	7	2429	1545	2125
4	UAL	All	2	1966	1126	--
4	CO	All	4	3022	786	1084
2	PSA	All	9	1889	985	1143
2	UAL	All	2	1208	1172	--
2	CO	All	4	1478	1062	1103
3	PSA	1	12	1133	670	829
3	PSA	2	9	1436	800	1170
3	UAL	1	3	866	670	--
3	UAL	2	2	923	667	--
3	CO	1	7	805	648	731
3	CO	2	1	1915	--	--

* PSA = Pacific Southwest Airlines
UAL = United Airlines
CO = Continental Airlines

Group 1 consists of aircraft detected at Sites 1 and 250
Group 2 consists of aircraft detected only at Site 250

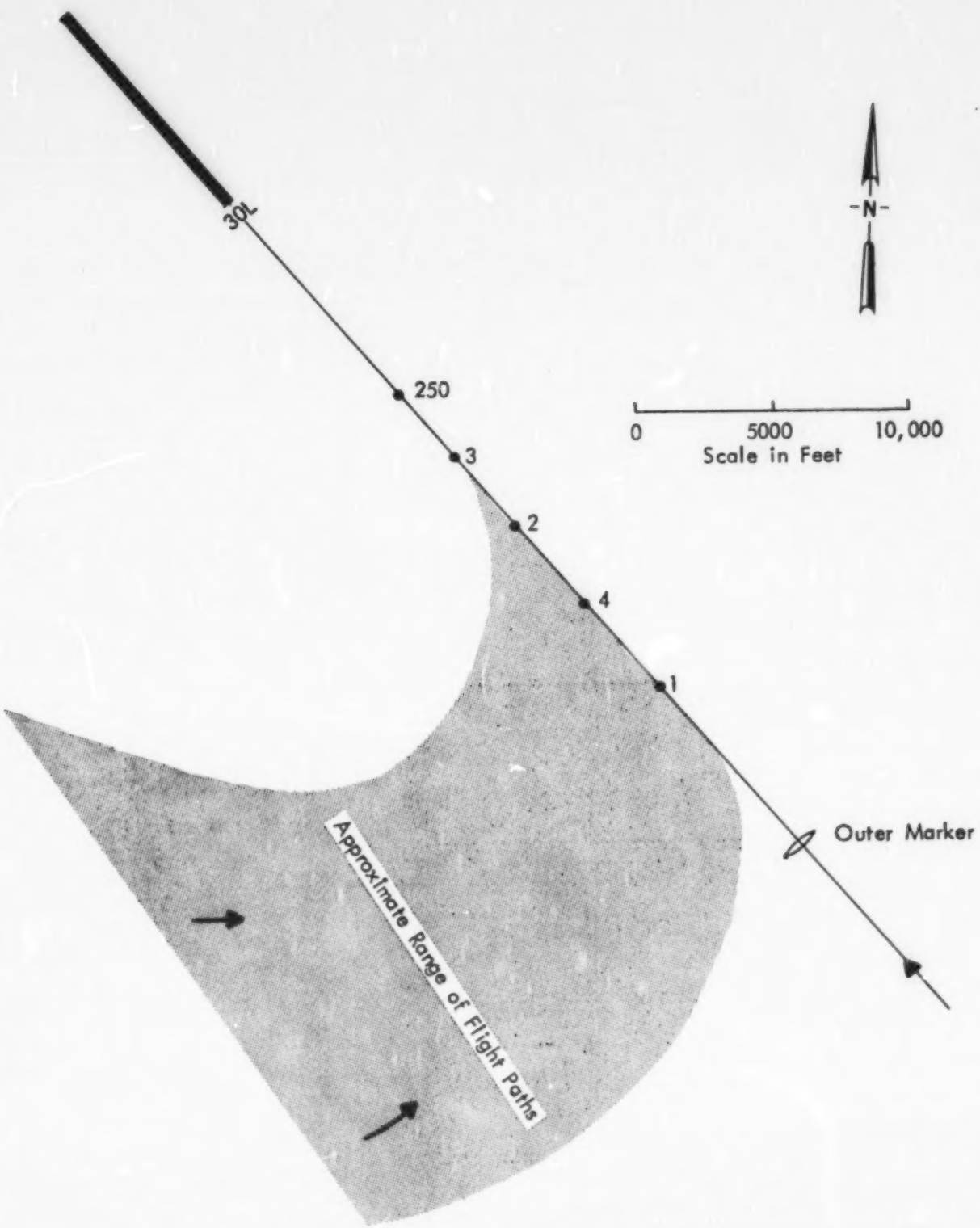

FIGURE 1. NOISE MEASUREMENT SITES AND FLIGHT PATHS

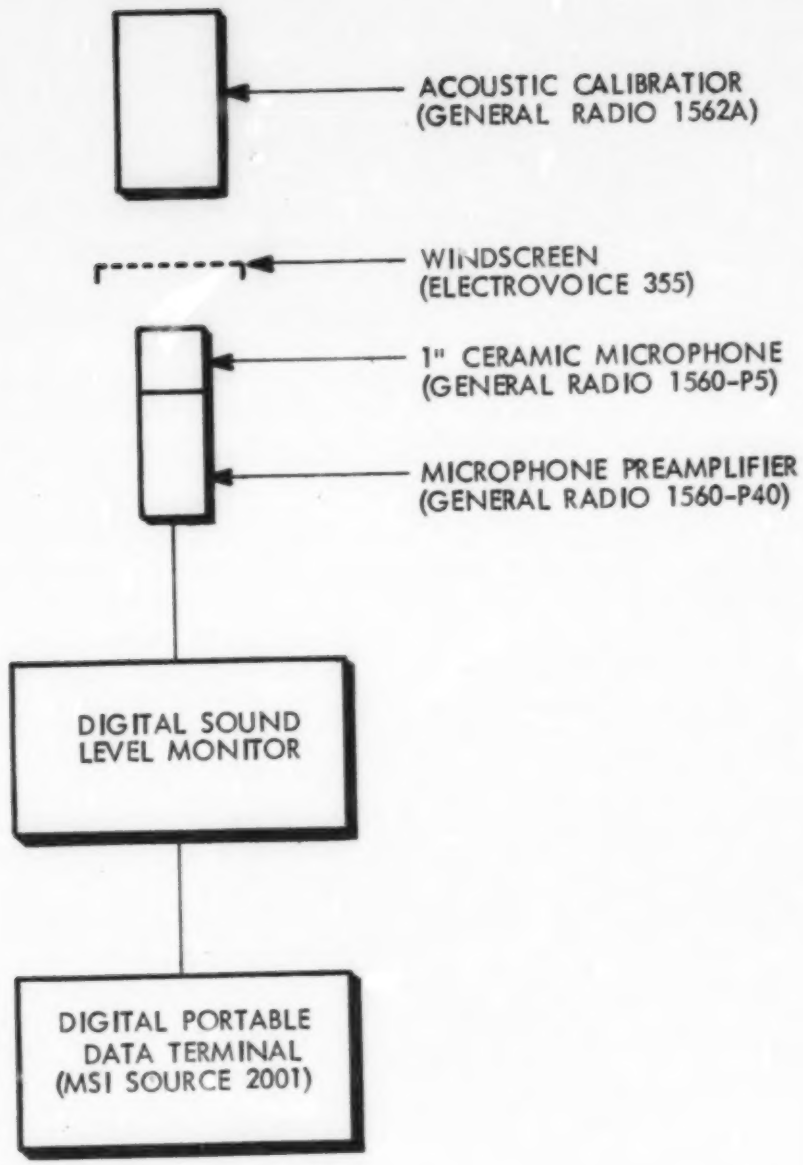

FIGURE 2. BLOCK DIAGRAM OF NOISE MONITOR EQUIPMENT

TIME	MAX	DUR	SENEL		
10:01.5	82.0	11	89.7	———	PS104
10:03.3	81.0	12	88.3		
<10:03.7	70.0	5	74.0		
10:12.5	78.0	2	79.9		
<10:12.6	70.0	4	74.3		
<10:18.5	67.0	1	67.4		
10:22.7	80.0	13	88.8	———	XK 616
10:26.8	75.0	4	79.3		
10:27.7	78.0	8	85.6		
10:30.6	85.0	9	92.0	———	PS 103
	80.0	7	85.4		
10:32.6	82.0	11	89.8	———	CO 301
10:34.7	89.0	6	94.8		
10:37.1	74.0	9	80.3		
10:41.4	81.0	9	87.8		
10:55.4	90.0	10	96.3	———	PS 261
10:57.3	82.0	7	88.6	———	RW 343 (F-27)
10:59.6	76.0	14	83.9		

$ HNL (1000 TO 1059) = 66.2

TIME	MAX	DUR	SENEL		
11:02.2	93.0	8	99.8	———	PS 1012
<11:06.4	69.0	1	70.0		
11:06.9	92.0	12	100.2	———	XK 505
<11:10.5	72.0	8	78.2		
11:24.7	94.0	7	100.2	———	RW 744
<11:28.0	70.0	10	78.2		
11:29.9	87.0	14	95.9	———	XK 617
<11:35.2	68.0	0	66.2		
11:49.2	92.0	8	98.4	———	PS 202
<11:55.1	71.0	5	76.5		
<11:56.0	70.0	3	73.3		

$ HNL (1100 TO 1159) = 70.6

FIGURE 3. SAMPLE OF NOISE MONITOR DATA

11795 SITE 3 RUN 75 727PSA

1/3 OCTAVE BAND CENTER FREQUENCY

50	63	80	100	125	160	200	250	315	400
MAXIMUM VALUES									
69.2	72.0	70.4	72.8	73.6	70.3	70.7	70.3	70.5	67.9
67.0	66.8	67.1	67.9	68.4	68.4	62.8	62.5	59.5	58.5
49.4	39.4	34.9	33.5						
AT PNLT MAX									
64.3	67.1	69.7	70.6	73.3	69.6	64.5	69.0	68.7	67.1
65.7	65.9	65.3	66.9	67.9	68.2	62.8	61.0	58.2	58.5
49.4	39.4	32.9	32.8						

NOISE LEVEL SUMMARY

MEASURE	TIME	MAX	10DB DUR	INTEGRAL
A-LEVEL	24.0	76.5	17.5	85.8
D-LEVEL	24.0	81.4	18.0	90.9
PNL	24.0	88.3	17.0	97.5
PNLT	21.5	89.6	16.5	98.1
TONE	10.5	2.7	(4000 HZ BAND)	

PNLC = 89.1 EPNL = 88.1 SENEL = 85.8

FIGURE 4. SAMPLE OF ANALOG DATA OUTPUT

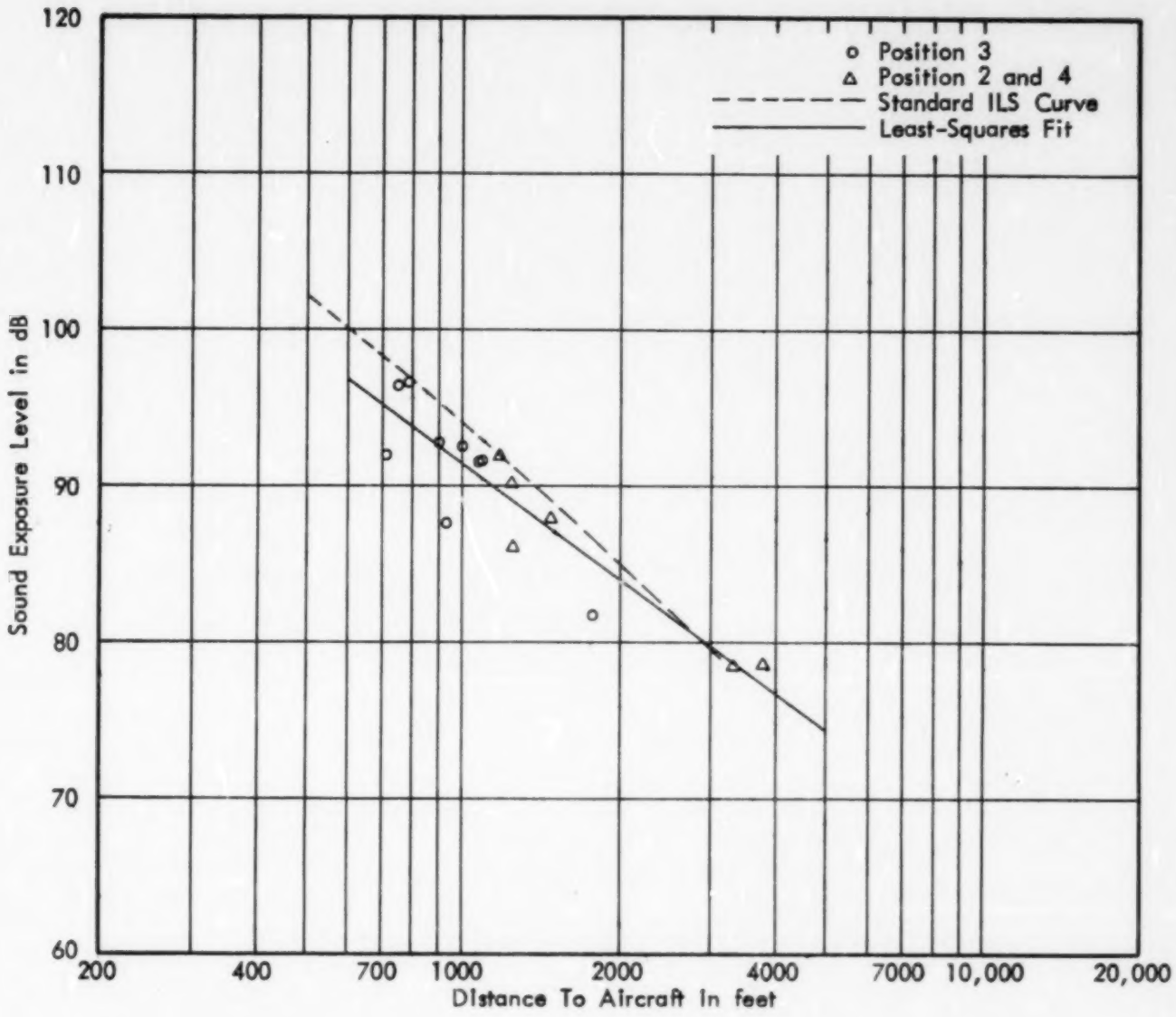

FIGURE 5. SEL FOR AIR WEST DC-9

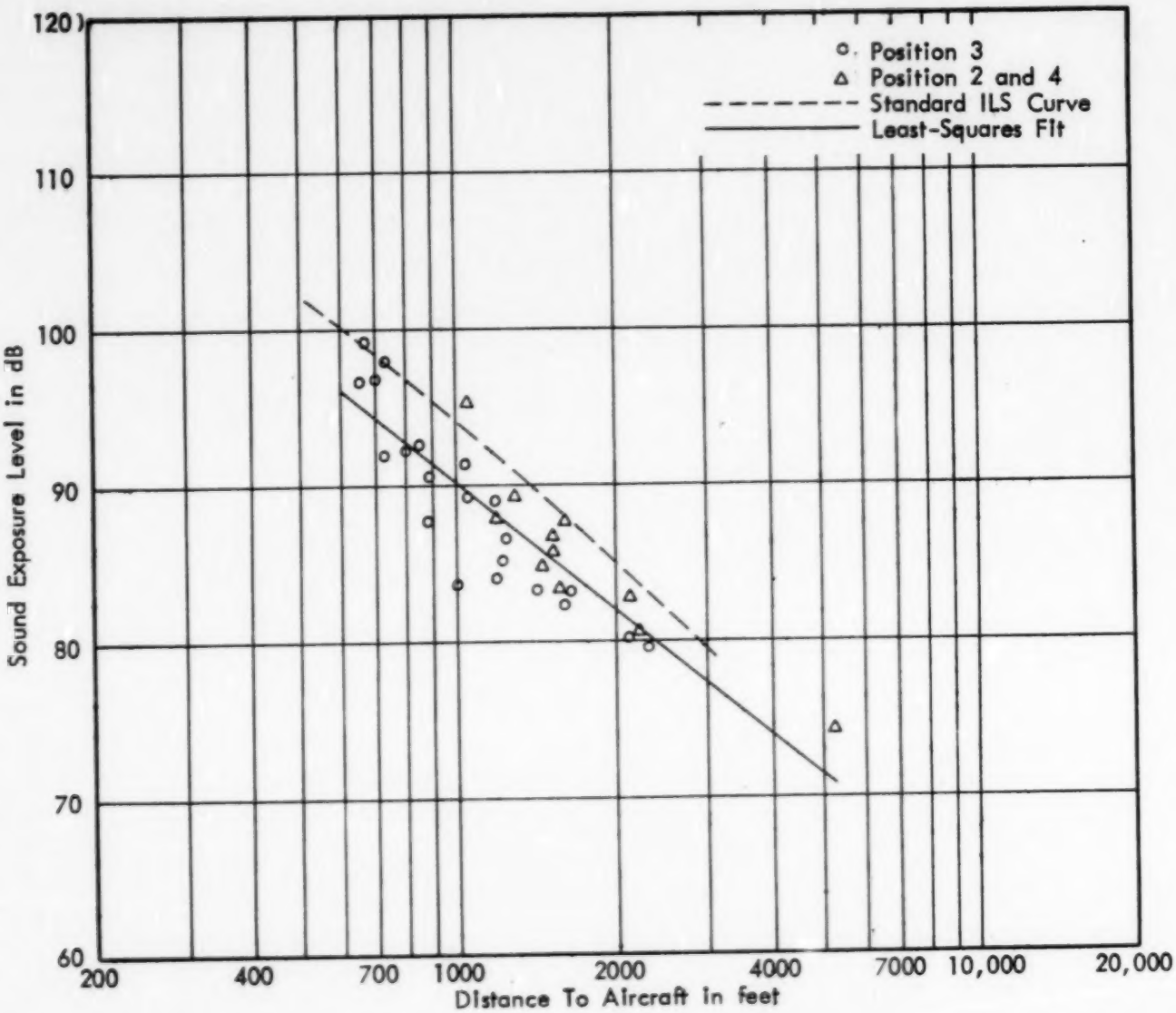

FIGURE 6. SEL FOR AIR CALIFORNIA 737

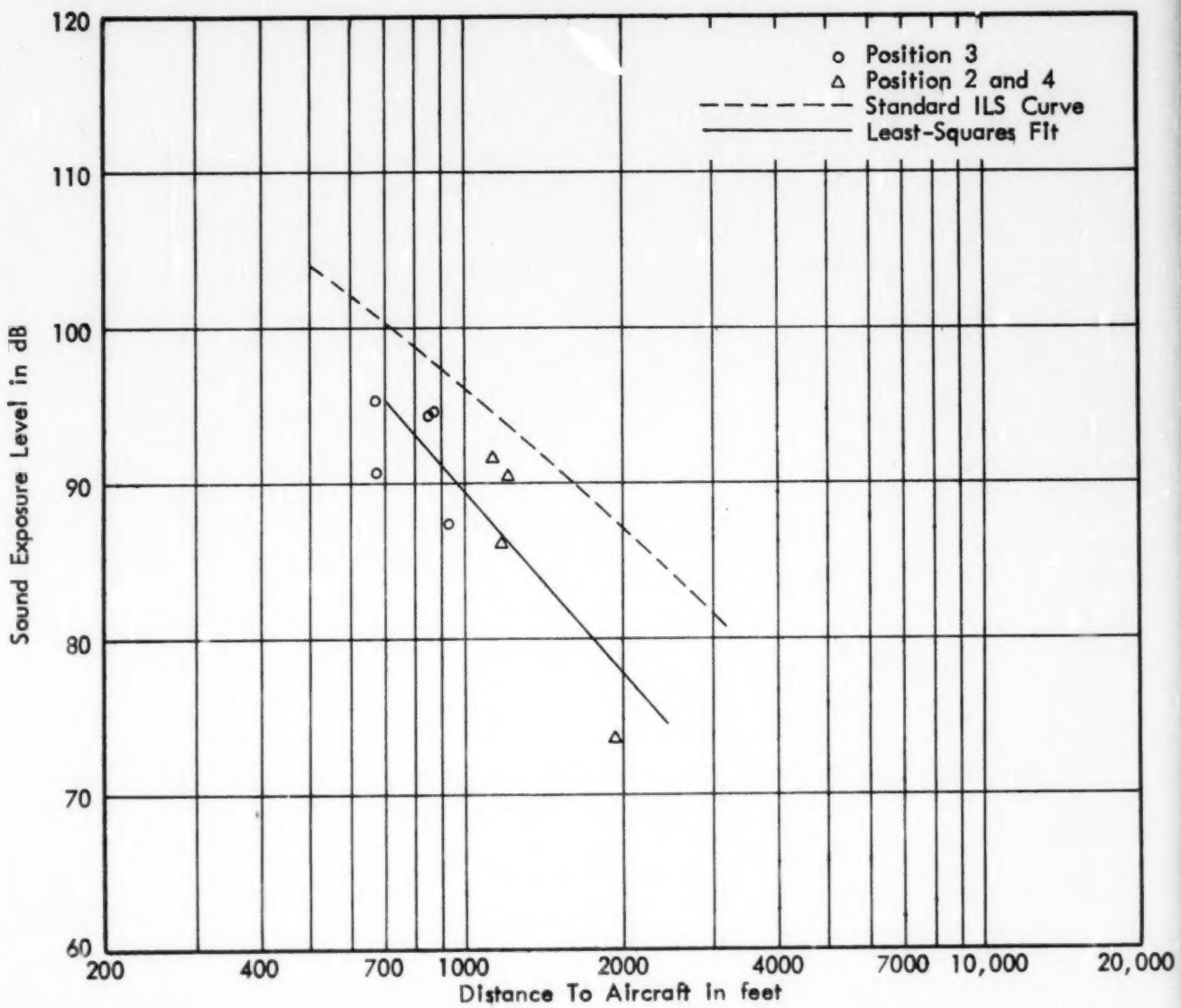

FIGURE 7. SEL FOR UNITED 727

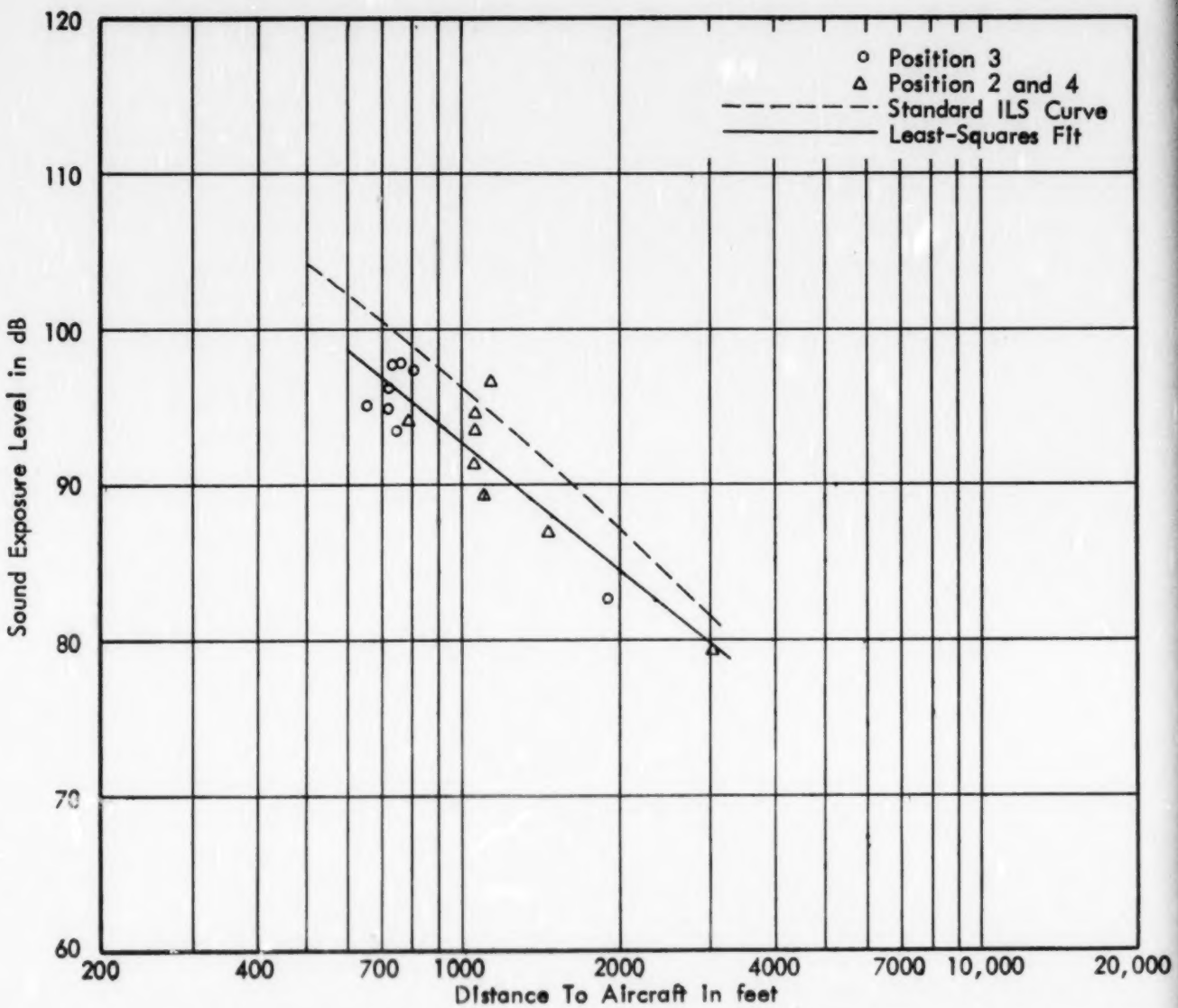

FIGURE 8. SEL FOR CONTINENTAL 727

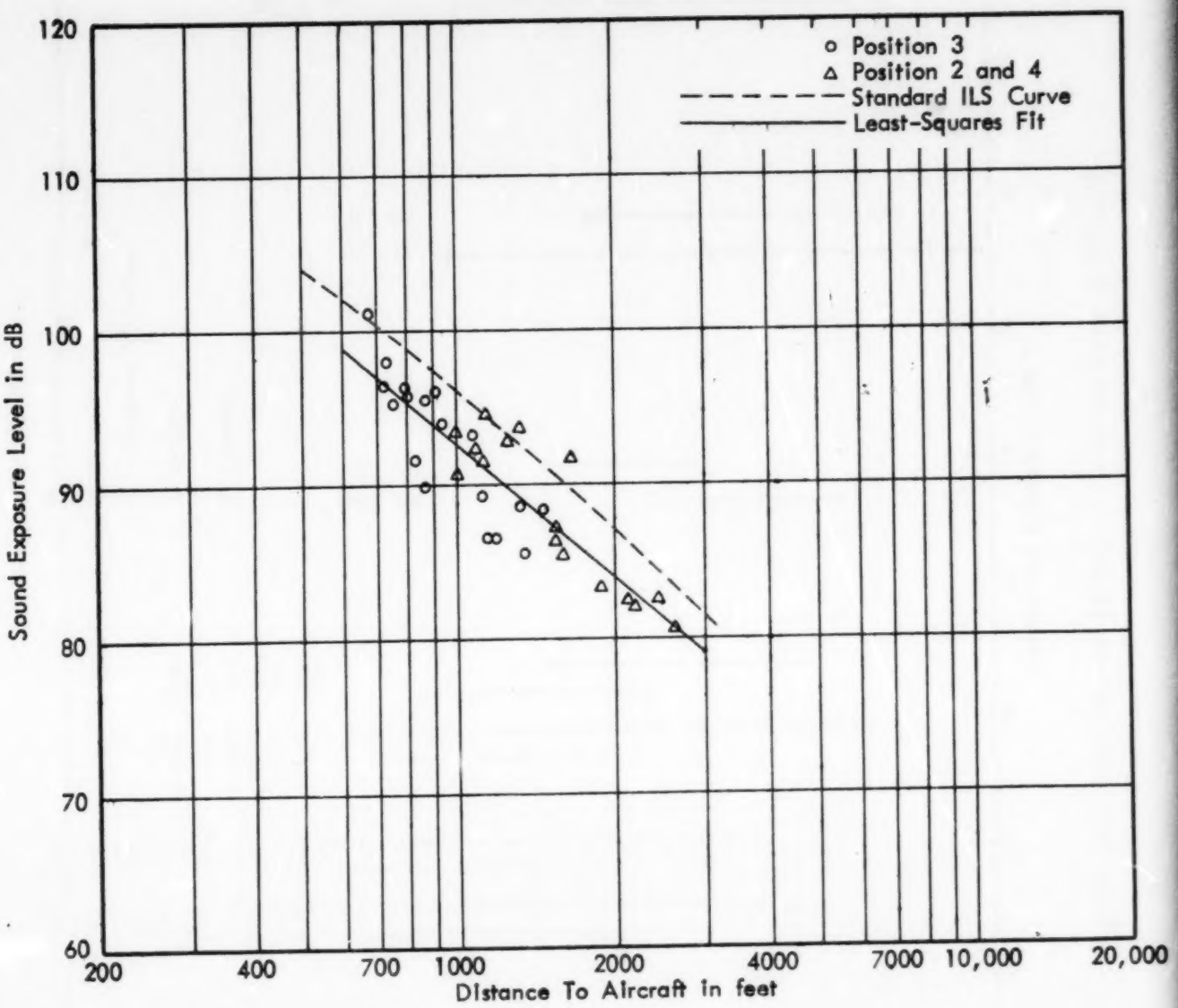

FIGURE 9. SEL FOR PSA 727

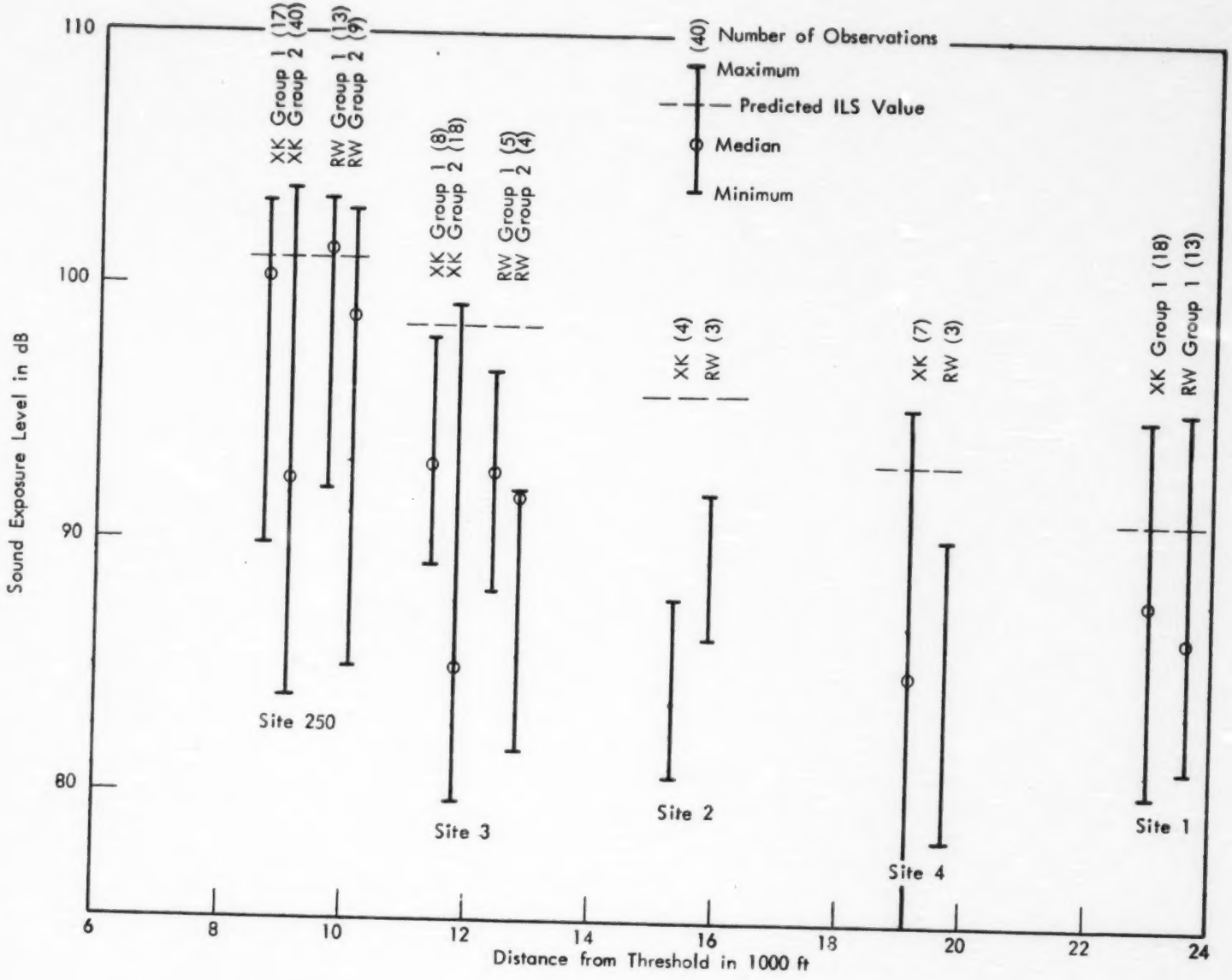

FIGURE 10. SITE NOISE LEVELS - TWO-ENGINE AIRCRAFT

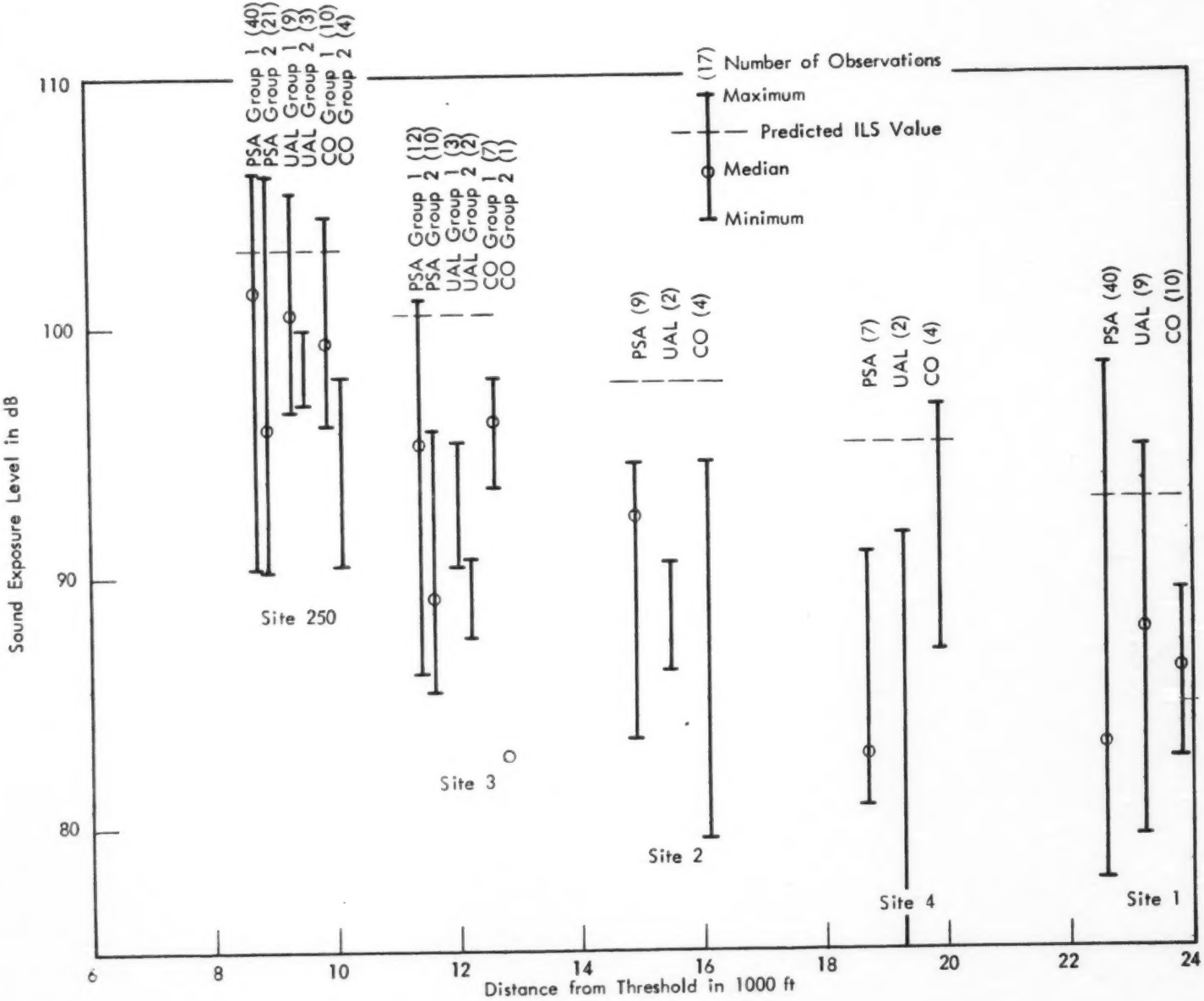

FIGURE 11. SITE NOISE LEVELS - THREE-ENGINE AIRCRAFT

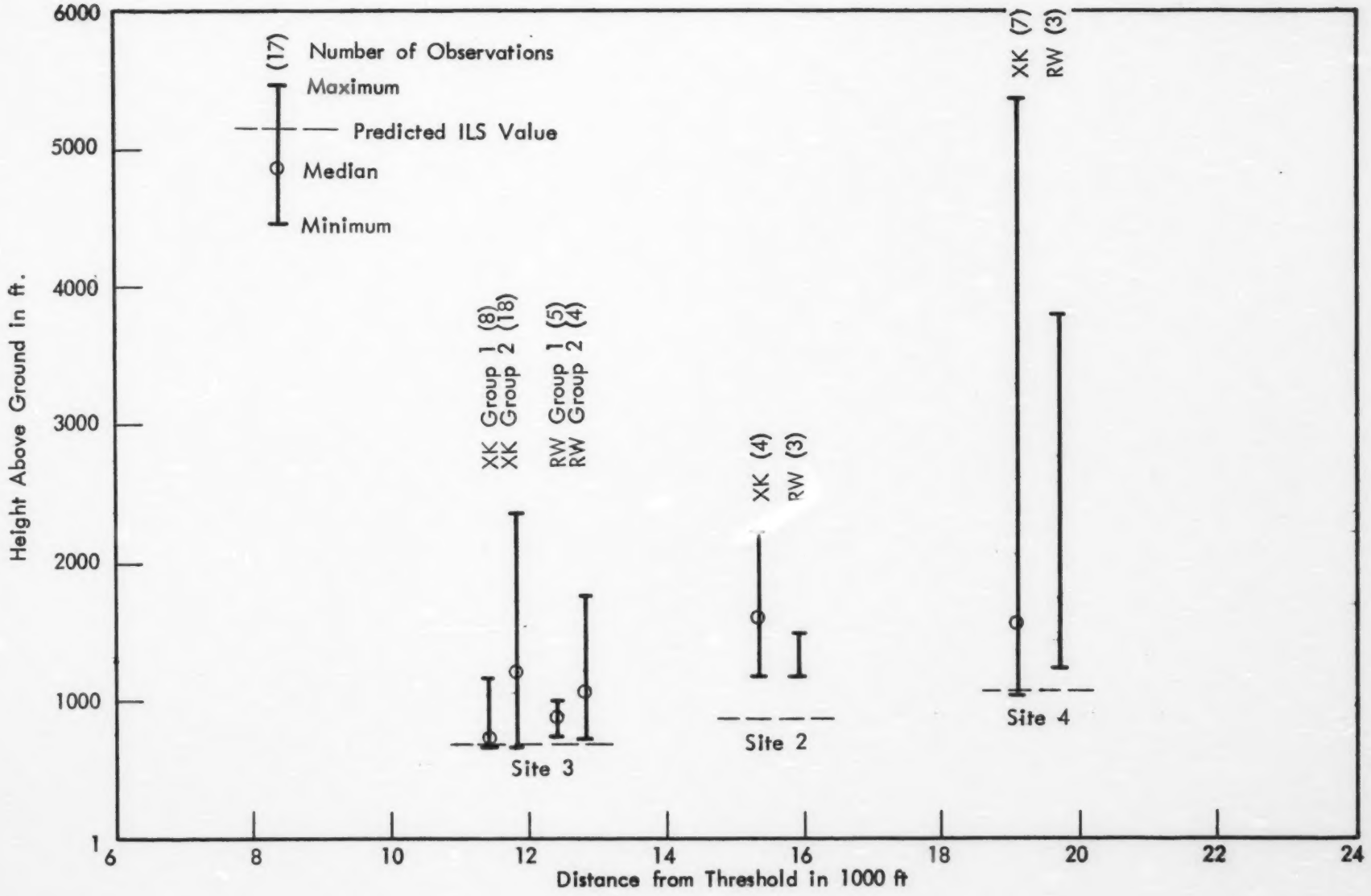

FIGURE 12. HEIGHT SUMMARY - TWO-ENGINE AIRCRAFT

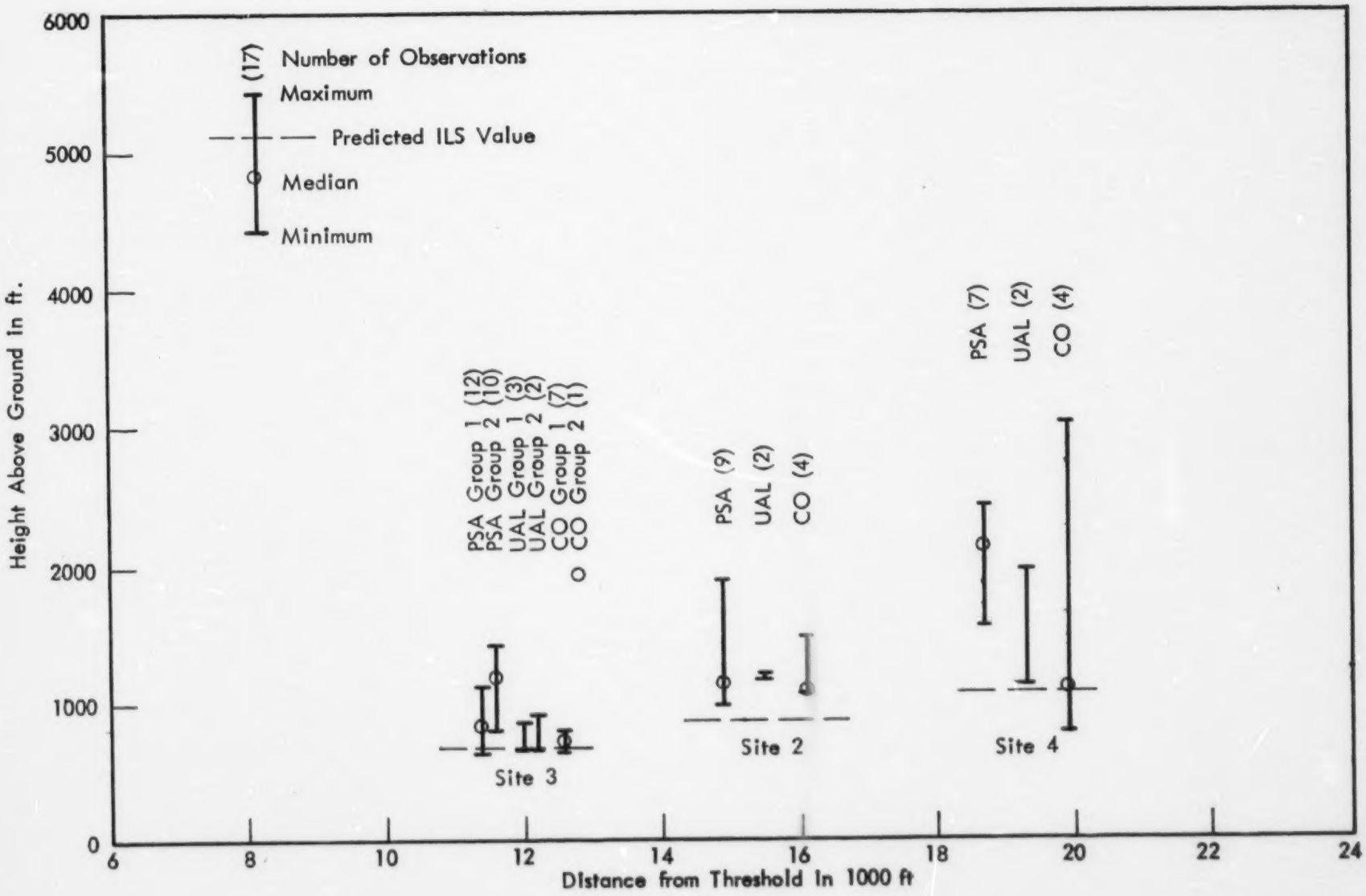

FIGURE 13. HEIGHT SUMMARY - THREE ENGINE AIRCRAFT

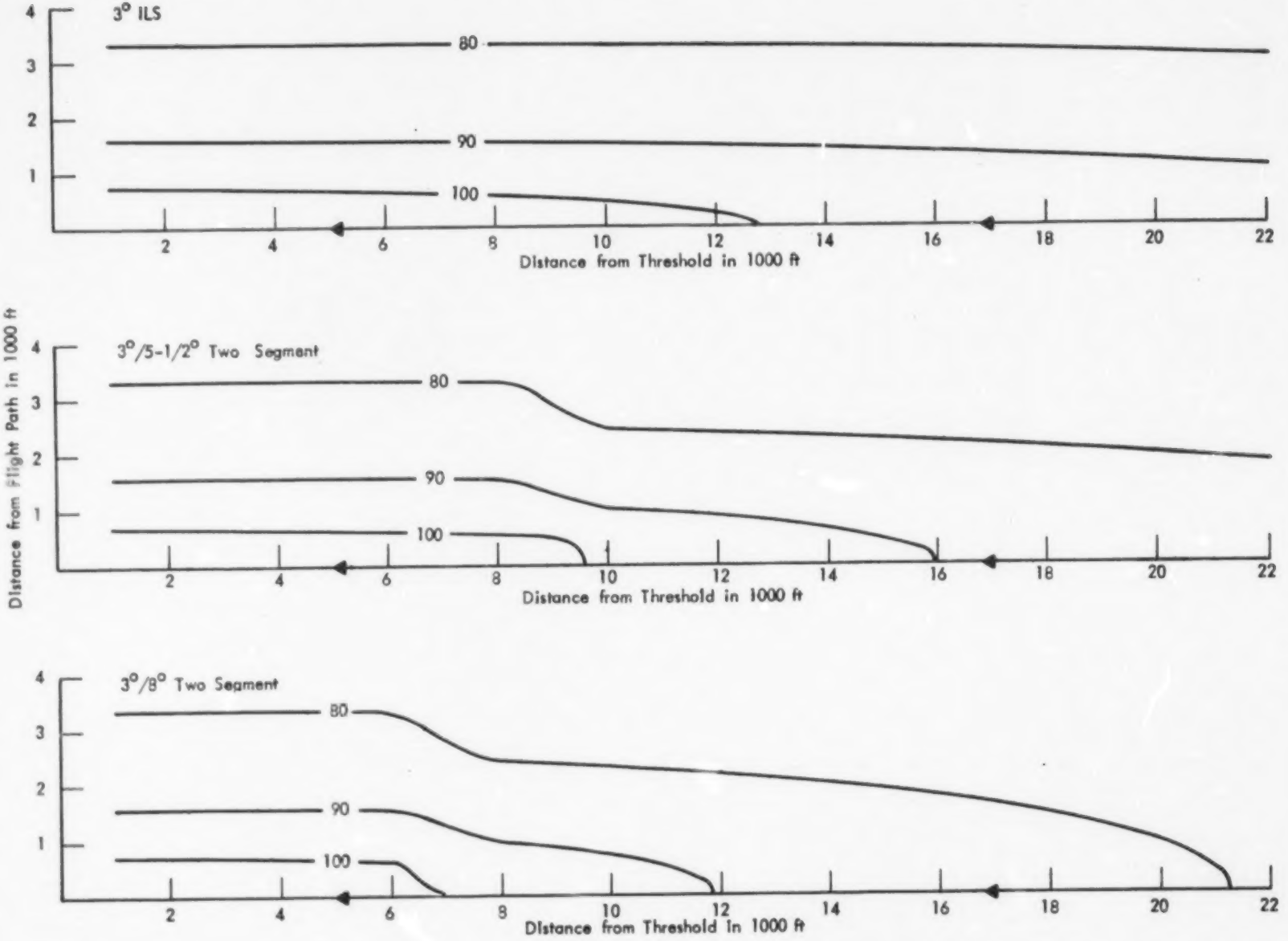

FIGURE 14. SEL CONTOURS FOR THREE APPROACH PROFILES